MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2017/2018

ETM2126 – INFORMATION THEORY AND ERROR CONTROL CODING

(TE)

2 MARCH 2018
9.00A.M. – 11.00A.M.
(2 Hours)

INSTRUCTIONS TO STUDENT:

1. This exam paper consists of **4 pages** with **4 questions.**

2. Attempt **ALL questions.** All questions have equal weightage and the breakdown of marks within each question is given.

3. Please write all your answers in the answer booklet provided. Show all relevant steps to obtain maximum marks.

Question 1

(a) Suppose the symbols of a data source are the outcomes of rolling a fair dice. What is the entropy of this source? What is the entropy of another source where the symbols are generated by rolling two fair dice?

[3 marks]

(b) Consider the sentence below:

streets are stone stars are not

i. Construct the Huffman codebook (by using the as-high-as-possible strategy).

(**Hints**: 1. Approximate the probability of each character based on the number of times the character occurs; 2. The space (" ") is consider as one character.)

[8 marks]

ii. Calculate the coding efficiency.

[4 marks]

(c) Consider the MMU Dictionary of the English Language, Second edition. This dictionary is used as a lookup table for encoding the following sentence:

go go gophers

Each word is encoded as (x, y), where, x gives the page in the dictionary and y gives the number of the word on that page.

i. If the dictionary has 2,200 pages with less than 256 entries per page, how many bits are needed for x and y respectively?

[2 marks]

ii. Discuss a problem with this coding technique and a possible solution.

[3.5 marks]

iii. Apply the Lempel-Ziv algorithm to encode the sentence above using the code format (Offset, Length, New character). Suppose the search buffer size and look ahead buffer size are 16 and 8 characters respectively.

[4.5 marks]

Continued...

Question 2

(a) Consider a binary symmetric channel with transition probability p as shown in **Figure 2.1.**

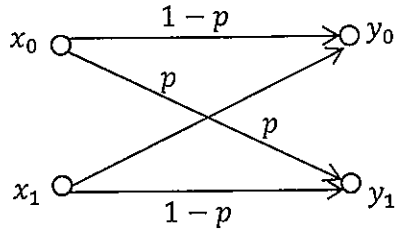

Figure 2.1

i. If the inputs of the channel have equal probability, show that the mutual information of this channel is given by

$$I(X;Y) = 1 + p\log_2(p) + (1-p)\log_2(1-p)$$

[8 marks]

ii. Suppose $p = 0.01$. Show that in order to achieve an arbitrarily low probability of error, the code rate (r) must be smaller than 0.9192.

[5 marks]

(b) An additive white Gaussian noise channel has a bandwidth of 5 MHz and signal-to-noise ratio of 15 dB.

i. Find the channel capacity (in bits/s).

[4 marks]

ii. Suppose the power spectral density of the noise is $\frac{N_0}{2} = 10\ \mu W/Hz$. If the bandwidth is increased to 10 MHz and the same transmit power is used, what is the channel capacity now?

[5 marks]

iii. Can the channel capacity be increased to infinity by increasing the bandwidth to infinity? Explain your answer.

[3 marks]

Continued...

Question 3

(a) Consider the (7,4) linear code with parity-check matrix given below,

$$H = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$$

(i) Determine the list of syndromes and its corresponding error pattern.

[4 marks]

(ii) If the vector 1001011 is transmitted but the vector 1001111 is received, show how this error can be corrected using syndrome decoding.

[4 marks]

(b) The generator polynomial of a (7,4) cyclic code is $g(D) = 1 + D^2 + D^3$.

(i) Find all the valid codewords of this code in systematic form.

[9 marks]

(ii) Develop the encoder circuit and find the codeword for the message 1010.

[8 marks]

Question 4

(a) Explain briefly the features of Trellis coded modulation (TCM) system in attaining effective utilization of bandwidth and power.

[5 marks]

(b) By using set partitioning approach, draw a diagram to illustrate the partitioning of a rectangular constellation corresponding to 16-QAM.

[8 marks]

(c) Given that the ½ rate convolutional encoder defined by $g^{(1)} = [1\ 1\ 1]$ and $g^{(2)} = [1\ 0\ 1]$, received a sequence of 0100010000. Show how Viterbi algorithm can be used to decode the original transmitted all-zero sequence.

[12 marks]

End of Paper